

§17. High Voltage Test of Liquid Stub Tuner on ICRF Heating R & D System

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The liquid stub tuner was fabricated to test how high it works in RF voltage. It is 260cm long and made of aluminum in outer transmission line and of copper in inner transmission line, whose diameters are 204mm and 104mm, respectively. The characteristic impedance without liquid is 50Ω . A cooling water flows inside the inner transmission line. It was installed under the conventional stub tuner on the oscillator side of ICRF heating R&D system^[1]. Two combined stub tuners work as a twin stub tuner^[2].

First we obtained an impedance matching with operating frequency, 50MHz when a normalized length of the conventional stub tuner was 0.25. In this case, the level of the liquid stub tuner was 85cm high. The normalized length of the liquid stub tuner, βl was 0.538, calculated in a following equation as described in the previous section;

$$\frac{1}{Z_0 \tan \beta l} = \frac{1 - Z_G / Z_0 \tan \beta l \tan \beta G l_G}{Z_0 \tan \beta l + Z_G \tan \beta G l_G} \quad (1)$$

Then RF voltage was measured in 8 different positions by RF probes in the liquid stub tuner as shown in Fig.1. In this figure, original point on the abscissa is the cross junction of the conventional stub tuner and the liquid stub tuner. The bottom of the liquid stub tuner is 285cm. The left side of the abscissa is a region of the conventional stub tuner. A 4W of RF power was transmitted to the whole system. RF voltages are plotted in this figure with that measured at the impedance matched section. As the normalized length of the liquid stub tuner exceeds 0.5, half of the RF wave length, small RF voltage exists near the cross junction. Here the liquid level is 200cm(85cm high from the bottom). It is found in this figure that the RF wave length becomes shorter in the liquid than in the gas(SF₆ gas was filled to increase RF breakdown voltage). The peak voltage in the liquid stub tuner, V_{Lmax} is 75V near the liquid surface. The maximum RF voltage, V_{max0} in the impedance matching system was 270V between the stub tuner and ICRF heating antenna. When 160kW of RF power was transmitted to this system, V_{Lmax} was 15kV without serious RF breakdown. This test duration was half second due to occurring parasitic

oscillation in RF oscillator. In other operation, the liquid stub tuner could endure with $V_{Lmax}=5-6kV$ for 50sec. We are planning to test it at 10kV level in several ten minutes operation.

On the other hand, we had efforts to reduce RF voltage at the liquid stub tuner. As far as the combined twin stub tuner works at 0.538, impedance matching conditions were always obtained. In this experiment, the normalized length of the conventional stub tuner, A1 was changed from 0.05 to 0.25 and the maximum RF voltage, V_{Lmax} was measured at the liquid stub tuner. Figure 2 shows the dependence of RF voltage ratios of V_{Lmax}/V_{max0} on A1(V_{max0} is constant). We can reduce the RF voltage ratio less than 0.1. Even when 3MW RF power is injected to the LHD plasma in 5Ω of its plasma loading resistance, V_{Lmax} will be reduced to 3.5kV at A1=0.05.

References

- 1)Kumazawa, R., et al., Annual Report 1992-1993, 52.
- 2)Kumazawa, R., et al., Annual Report 1992-1993, 53.

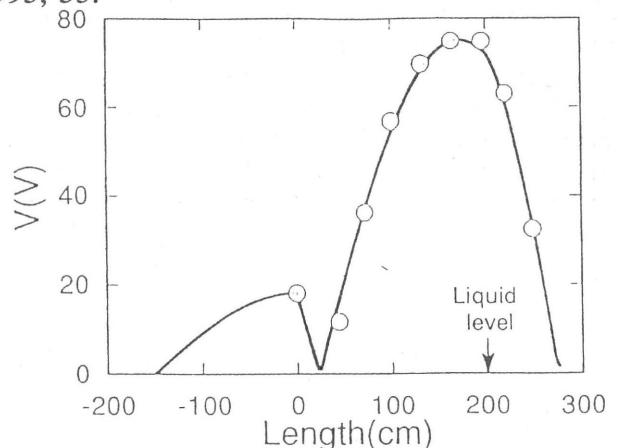


Fig.1 RF voltage distribution in liquid stub tuner.

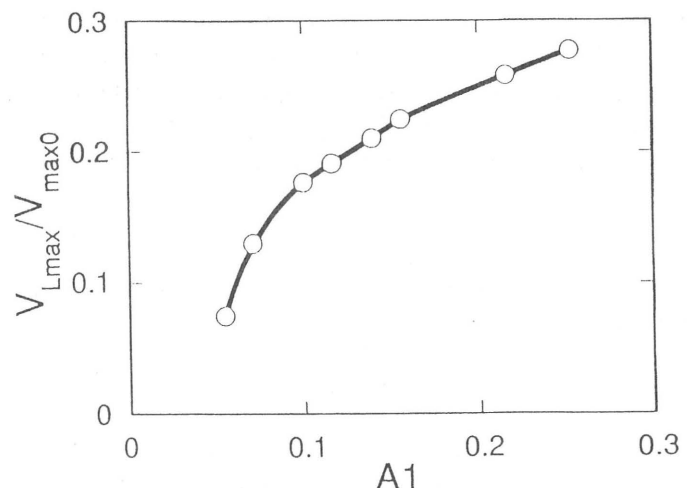


Fig.2 Dependence of RF voltage ratio, V_{Lmax}/V_{0max} on normalized length of stub tuner, A1.